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THE TOXIC OR REPELLENT ACTION TO THE EUROPEAN CORN BORER OF CORN PLANTS GROWN IN SOIL TREATED WITH VARIOUS COMPOUNDS

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In 1944 experiments were begun in Toledo, Ohio, to determine whether certain insecticides applied to the soil in corn fields would be absorbed by the plants and thereby make the plants toxic or repellent to the European corn borer (Pyrausta nubilalis (Hbn.)). The results obtained through 1949 are reported herein.

Several hundred compounds were tested. Many of them were investigated under code numbers and some have not been decoded. Compounds that did not show promise in these tests are not listed in this paper. Names of such compounds will be supplied upon request if they have been decoded.

In the sieving tests insufficient quantities of materials prevented replication. Though unreplicated tests are not entirely satisfactory and results may indicate valueless materials as being promising, if any compounds were valuable, high borer populations should be no more likely to occur in replicated plots than in a single plot. However, replication without variation of treatment would not assist in more definitely evaluating a compound. It is felt that further tests at varying dosage rates and time of application in relation to infestation should be investigated before such compounds can be said to be worthless as chemotherapeutic agents.

Tests in 1944

On April 27, 1944, 521 materials were each applied to single hills of corn at time of planting. Four kernels of Spancross sweet corn and 1 gram or more of a single compound were placed in each hill and covered shallowly with dirt. Many of these chemicals prevented germination of the corn seed. Others apparently acted as fertilizers, causing the corn to break through the ground ahead of the rest and to continue early growth at an accelerated rate. When the plants were approximately 6 inches high, they were thinned to 2 plants per hill. When in the roasting-ear stage, all plants were dissected to determine the average number of borers per plant.

Plants treated with 24 of these compounds, when mixed with soil, had an average of less than 3 borers per plant. Dissections of the plants showed that in 6 hills there were no borers, 6 averaged 1 borer per plant, 12 averaged 2, 16 averaged 3, 10 averaged 4, and 13 averaged 5. The remaining hills averaged 6 to 51 borers per plant.

Plants from 20 untreated hills were also dissected. They averaged 3 to 24 borers per plant. The average for all plants, including checks, was slightly less than 13 borers per plant.

Tests in 1945

Of the 63 most promising materials tested in 1944, 25 were retested in randomized replicated plots in 1945. These compounds were mixed with equal parts of kaolin, and at the time of planting on April 12 approximately 1 gram of active material was placed with several kernels of corn in each hill. The corn was thinned to 2 plants, when they were approximately 6 inches high. These two-plant hills were replicated five times for each treatment.

Owing to various causes, sometimes including possibly the action of the chemical itself, more than half the treatments contained fewer than 10 plants at dissection time. Weather conditions early in the spring of 1945 were unfavorable for good germination and for rapid growth of sweet corn. These conditions and a high population of seed-corn maggots (Hylemya cilicrura (Rond.)) were the chief cause of a poor stand and also of less uniformity of plant size and vigor than would occur in a more normal year.

On June 19 at the time the first European corn borer eggs were being laid and on July 7 near the end of the oviposition period, height measurements of the corn plants were recorded.

On July 24, when the plants were in the roasting-ear stage, all were dissected and the average number of borers per plant was determined. The entire plant including tillers was dissected. Table 1 gives the borers found in each replicate, and the average number of borers per plant for each treatment.

Borer populations averaged 4.8 to 20.5 per plant in the treated hills and 13.4 borers in the untreated hills.

In 1945, 156 other compounds were given a preliminary trial. This test was conducted in the same manner as the foregoing test. Height of plant and number of borers per plant were recorded. Dissections of the plants made on July 25 and 26 at roasting-ear stage showed an average borer population per plant ranging from 0 to 29 for treated plants and from 6 to 20 for the check plants.

Plants treated with 11 of the compounds showed an average of less than 3 borers per plant. Two of them—pyrethrum and 4,6-dinitro-m-tolyl methyl ether—were given further tests in succeeding years.

Table 1.--Number of borers per plant found at roasting-ear stage in replicates grown in soil treated with various compounds, 1945

Compound	Borers per plant in replicate[1]					Average per plant
	No. 1	No. 2	No. 3	No. 4	No. 5	
2,5-Xylidene, N-benzylidene-	6[2]	9	9	-	-	4.8
Azobenzene	11	6[2]	7	16	11	5.7
Phthalimide, N-(m-tolyl)-	13	19	13[2]	15	3	6.3
Acetophenone, 3,4-dichloro-	4[2]	22	2[2]	11	-	6.5
Benzoic acid, p-chloro-	9	11	15	19	-	6.7
Ether, 4,6-dinitro-m-tolyl methyl	14	12	14	21	9	7.0
Piperidine, 1-(p-nitrophenyl)-	15	8[2]	8	18	-	7.0
Phenazine	11[2]	9[2]	15	13	-	8.0
Sulfonal	11	17	17	0	36	8.1
Phenol, 2,6-dibromo-4-nitro-	5	3[2]	8	28	14	8.2
Benzene, alpha,beta-dibromo-beta-nitroethyl-	0[2]	12[2]	23	15	-	8.3
Benzophenone, 4,4'-diamino-	21	18[2]	20	12	-	8.8
Benzoic acid, o-benzoyl-	7[2]	16[2]	6[2]	16	-	9.0
Phthalimide, N-(o-nitrophenyl)-	24	38	20	7	7	9.6
Piperidine-piperidinecarbo dithiocarbamate	6[2]	30	7[2]	21	13	9.6
p-Toluenesulfonanilide, N-ethyl-	8[2]	28	16	12	25	9.9
Isatin	26	25	23	9	17	10.0
Aniline, N-isobutyl-2,4-dinitro-	19	11	27	29	8[2]	10.4
2-Pentanone, 4-methyl-semicarbazone	25	13[2]	19	17	-	10.6
9,9-Dimethylacridan	12[2]	25	16	2[2]	31	10.8
9-Fluorenone	7[2]	21	30	8[2]	-	11.0
Diphenylamine, N-methyl-2,4-dinitro-	4[2]	28	19	35	14	11.1
1,3-Benzodioxan, 6-nitro-	15	10[2]	24	39	13	11.2
o-Benzenesulfonoanisidide	30	24	18	20	-	11.5
Mandelonitrile, alpha-(1-piperidyl)-	44	36	28	45	52	20.5
Check	18	33	20	11[2]	39	13.4

1/ Two-plant hills unless indicated otherwise.
2/ Single-plant hills.

Tests in 1946

Eight materials that had shown promise in tests in previous years were placed in the hills at the time the corn was planted on April 16, 1946. Each material was randomized in five replicate hills. Five grams of material was placed in each hill. When the corn was approximately 1 foot high, the plants were thinned to 3 per hill.

On June 10 observations were made to determine the relative thriftiness and condition of the plants. Height measurements of the corn plants were taken on June 13 at the start of oviposition, on June 25, which was the approximate mid-oviposition date, and on July 8, which was the end of the oviposition period.

Some of the materials at the 5-gram dosage rate appeared to affect the corn adversely, even destroying some plants. Both 3,4-dichloroacetophenone and phenazine produced an injurious effect, not only killing plants but stunting the growth of those that did survive. At the end of the oviposition period plants growing in soil treated with these two chemicals were not more than 27 inches high, compared with 38 inches or more for plants growing in untreated soil and in soil receiving many other treatments.

On July 15, when the corn had reached the roasting-ear stage, all plants were dissected and the borers contained in each plant recorded. Data on the results of the 1946 observations are shown in table 2.

4,6-Dinitro-m-tolyl methyl ether appeared to be the most promising of the materials tested. The plants were high enough to attract moths for oviposition, and all 15 plants survived. Both DDT and pyrethrum appeared to have little effect upon the borer in these field tests.

Table 2.—Condition of plants grown in soil treated with various compounds, average height, and number of plants and of borers surviving, 1946

Compound	Condition of plants on June 10	Average height on—			Plants	Borers	Average borers per plant
		June 13	June 25	July 8			
		Inches	Inches	Inches	Number	Number	Number
DDT (20 percent micronized on clay)	Good	20.4	30.4	40.8	15	43	2.87
Pyrethrum powder (100 percent)	Good	20.6	28.4	38.8	15	68	4.53
Azobenzene	Fair to good	16.8	27.0	38.0	15	16	1.07
2,5-Xylidene, N-benzylidene-	Fair	15.4	26.0	36.8	11	5	.45
Benzoic acid, p-chloro-	Good	18.8	27.6	34.4	14	25	1.79
Acetophenone, 3,4-dichloro-	Poor	10.4	14.8	27.0	9	1	.11
Ether 4,6-dinitro-m-tolyl methyl	Good	16.0	25.8	36.8	15	2	.13
Phenazine	Very poor	12.4	17.2	25.5	8	2	.25
Check	Good	18.8	28.8	38.6	15	36	2.40
	Good	19.8	29.0	40.2	14	55	3.93

Tests in 1947

Tests with DDT, Pyrethrum, and 4,6-Dinitro-m-tolyl methyl ether.—In the spring of 1947 these three materials were applied to plots replicated four times for each treatment. Each plot was 1 row 15 feet long. Approximately 1/2 pound of insecticide was mixed with soil in each plot before the corn was planted. A few days after being planted, the rows were covered with waxed paper supported by wires in the shape of an inverted U. The papers were removed when the plants were approximately 8 inches high. The waxed paper was used to promote early germination and rapid growth and thereby induce heavy oviposition by the European corn borer moths to provide more reliable tests. The highest populations observed in the Toledo area in 1947 were found in this experiment. 4,6-Dinitro-m-tolyl methyl ether appeared to affect the plants adversely, as they were less thrifty than the rest. When the corn plants reached the roasting-ear stage, they were dissected. Borer populations are shown in table 3. The plants treated with 4,6-dinitro-m-tolyl methyl ether contained the fewest borers, possibly because of the poor plant growth resulting from the injurious effect of the chemical. Although all three compounds materially reduced the numbers of borers, none reduced infestations enough to offer much promise of being of practical value.

Table 3.—Borer populations per 100 corn plants grown in soil treated with various compounds, 1947

Compound	Yield of No. 1 ears		Borer population		Reduction of borers in—		Plants borer free
	Total	Borer free	In plants 1/	In ears 2/	Plants	Ears	
	Number	Percent	Number	Number	Percent	Percent	Number
Ether, 4,6-dinitro-m-tolyl methyl	118	27.9	893	440	60.7	51.5	8
DDT, 25 percent	118	6.8	1,200	535	46.4	41.1	0
Pyrethrum	100	8.0	1,405	620	38.2	31.7	0
Check	115	0	2,275	908	-	-	0
Difference required for significance at odds of 19 to 1:			322	128			

1/ Entire plant including tillers.
2/ All ears including culls.

Tests with Parathion.— In 1947 tests were also made with parathion. The first investigations were made in the greenhouse and laboratory with corn grown in 5-inch flowerpots containing soil that had been mixed with approximately 2 grams of this material. When the stalk portions of plants were 10 inches high, sections of leaves and of stalks were placed in glass test tubes each containing two egg masses in the "blackhead" stage which just precedes hatching. The leaves were cut into 1-inch sections, rolled into a small coil, and inserted into the tubes. The sections of stalk were partially split before being placed in the tubes to permit entrance of larvae. A cotton-filled cloth stopper was used to close the mouth of the tube. Test periods ran for 48 hours, during which time many observations were made without the larvae being disturbed. At the end of the test a record was made of dead and living larvae and the amount of feeding. This procedure will be referred to as the standard laboratory technique elsewhere in this paper. All the European corn borers feeding on these corn plants were killed in less than 24 hours.

It was suggested that the compound was giving off gases that were absorbed by the wax on the corn leaves and that the larvae might have been killed by fumigation. Newly hatched European corn borer larvae and second and third instars of the fall armyworm (Laphygma frugiperda (A. & S.)) were therefore placed in small glass dishes together with untreated corn leaves for food, and the dishes inverted on soil that had been heavily treated with the compound. After 72 hours of exposure the mortality was no higher than normal.

Other fall armyworm larvae were placed on a 20-mesh wire screen over 50-ml. open dishes each containing a gram of the compound. The larvae were confined on the screen by inverting a similar dish over them. These containers were placed in a greenhouse for 24 hours, during which time mortality was no higher than normal.

Tests were conducted in the greenhouse and laboratory by the standard technique to determine the period during which parathion was toxic in the corn plants. When the compound was mixed with the soil at the time of planting, evidence of toxicity began to appear on the 15th day after planting. The peak of toxicity was reached on the 21st day, and by the 24th day most of the toxicity had been lost.

Corn plants 8 inches high, growing in flowerpots in the greenhouse, were side-dressed with a water suspension of parathion. On the 2nd day thereafter the leaves began to show toxicity to first-instar larvae and by the 5th day complete mortality was obtained. After the 8th day there was a rapid drop in mortality, and on succeeding days no more than 13 percent mortality was observed in any tests conducted with the leaves. Stems taken from these plants caused 90 percent mortality on the 3rd day after treatment. Complete mortality was observed on the 5th day and continued until after the 13th day.

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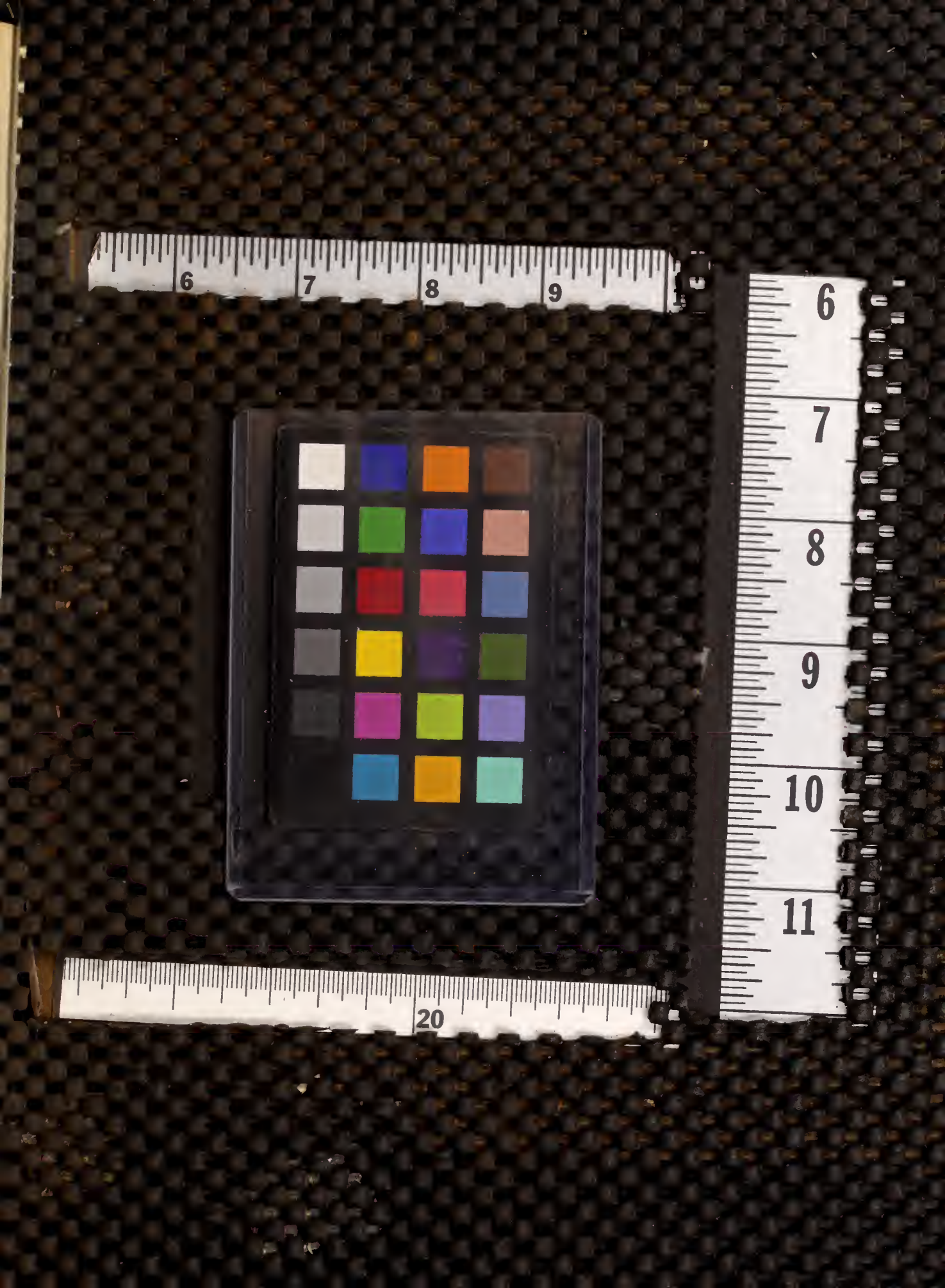
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